TITLE:
<Division of Synthetic Chemistry> Advanced Inorganic Synthesis

AUTHOR(S):

CITATION:
<Division of Synthetic Chemistry> Advanced Inorganic Synthesis. ICR Annual Report 2007, 13: 10-11

ISSUE DATE:
2007-03

URL:
http://hdl.handle.net/2433/65544

RIGHT:

京都大学学術情報リポジトリ KURENAI 紅
Kyoto University Research Information Repository

Division of Synthetic Chemistry
- Advanced Inorganic Synthesis -

http://msk2.kuicr.kyoto-u.ac.jp/~shimak-lab/indexE.html

Prof
SHIMAKAWA, Yuichi
(D Sc)

Assoc Prof
AZUMA, Masaki
(D Sc)

Assist Prof
IKEDA, Yasunori

Res
KAN, Daisuke
(D Sc)

Students

NISHIMURA, Kousuke (D1)
KAWAI, Masanori (M2)
SAKAI, Maiko (M2)
KASAI, Naoko (M1)
KOMATSU, Hiroshi (M1)
SHIRAKI, Hiroshi (M1)

Scope of Research

Transition-metal oxides show lots of interesting and useful properties. They include ferroelectrics, ferromagnets, conductors, batteries, and so on. These materials are widely used in current electronic devices. The wide variety of their crystal structures gives rise to various electronic structures, which lead to interesting and useful physical and chemical properties. We are focusing on the fundamental physics and chemistry of these “functional oxides” and seeking new materials with new functions. We are conducting systematic studies of material synthesis based on phase equilibrium information. Precise crystal structures are analyzed by X-ray and neutron diffraction. Electronic and magnetic structures are discussed based on the results of electronic structure calculations and physical property measurements.

Research Activities (Year 2006)

Presentations

Magnetic Ferroelectrics Bi,Pb-3d Transition Metal Perovskites: Azuma M, Takata K, Saito T, Shimakawa Y, Takano M, Niitaka S, Belik A A and Ishiwata S, APS March Meeting 2006, Baltimore, USA, 16 March 2006.

Fabrication and Characterization of Multiferroic Bi_2NiMnO_6 Thin Films: Sakai M, Kan D, Azuma M, Takano M and Shimakawa Y, 67th Autumn Meeting of the Japan Society of Applied Physics, Kusatsu, Japan, 30 August 2006.

Structural Characterization of Epitaxial $BaTiO_3$ Thin Film by Synchrotron X-Ray Diffraction: Kawai M, Kan D, Sakata O, Kimura S and Shimakawa Y, 67th Autumn Meeting of the Japan Society of Applied Physics, Kusatsu, Japan, 29 August 2006.

Structural Study of $SrTiO_3$ Showing Room-Temperature Blue Luminescence: Kan D, Masuno A, Shimakawa Y, Sakata O and Kimura S, 67th Autumn Meeting of the Japan Society of Applied Physics, Kusatsu, Japan, 31 August 2006.

Blue-Luminescence from Electron-Doped Metallic $SrTiO_3$: Kan D, Ishizumi A, Kanda R, Masuno A, Terashima T, Kanemitsu Y, Takano M and Shimakawa Y, XIII International Workshop on Oxide Electronics, Ischia, Italy, 9 October 2006.

Grants

Shimakawa Y, Synthesis and Structural Characterization of New Functional Transition-Metal Oxides by Solid State Chemistry Approach, Grant-in-Aid for Scientific Research (B), 1 April 2006–31 March 2008.

Shimakawa Y, Invention of Anormalous Quantum Materials —New Physics through Innovative Materials— Scientific Research on Priority Areas, 1 April 2005–31 March 2007.

Azuma M, Search for Ferromagnetic Ferroelectrics in Lead, Bismuth-3*d* Transition Metal Double Perovskites with Controlled Arrangements of Elements, Natural Sciences Research Assistance, The Asahi Glass Foundation, 1 April 2005–31 March 2007.

Multiferroic Thin Film of Bi_2NiMnO_6 with Ordered Double-Perovskite Structure

Multiferroic materials, in which ferromagnetic and ferroelectric orders coexist, have attracted lots of attention for technological applications as well as fundamental physics. We have succeeded in fabricating thin films of newly found multiferroic compound Bi_2NiMnO_6 grown on the $SrTiO_3$ substrate by pulsed laser deposition. The epitaxially growth and the ordered double-perovskite structure of the thin films are confirmed by X-ray diffraction measurement. Ferromagnetic transition occurred at around 100 K. The observed saturated magnetization at 5 K is 4.2 μ_B/f.u., which is close to 5 μ_B/f.u. expected for the ferromagnetic ordering of Ni^{2+} (S=1) and Mn^{4+} (S=3/2) moments. The clear ferroelectric P-E hysterisis loop was also observed, and the saturated polarization was about 5 mC/cm^2 above 80 kV/cm at 7 K.

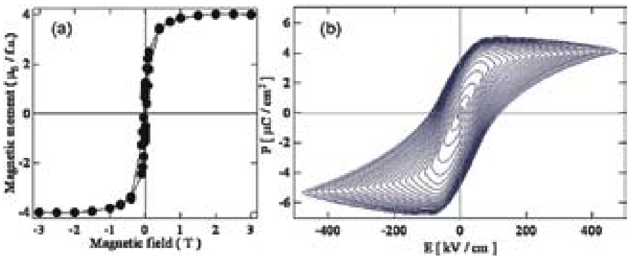

Figure 1. (a) Magnetization curve for Bi_2NiMnO_6 film measured at 5 K which shows the ferromagnetic oredeing of Ni^{2+} and Mn^{4+} moments. (b) Ferrolelctric P-E hysterisis curve measured at 7 K.

Half Metallic Ferrimagnet $BiCu_3Mn_4O_{12}$

Considerable attention has been paid to colossal magnetoresistance (CMR). Large MR at a low applied field above room temperature (RT) is highly desirable from practical application point of view.

A cubic ordered perovskite $BiCu_3Mn_4O_{12}$ is a newly found low-field MR compound. This compound is synthesized at a high-pressure of 6 GPa and at 1000ºC. $BiCu_3Mn_4O_{12}$ is ferrimagnet below T_C = 350 K and its saturated magnetic moment is 10.5 m_B/f.u. at 5 K. It shows low resistive metallic behavior. Magnetoresistance (MR) is observed over a wide temperature range below T_C, and the MR below 1T reaches 28% at 5 K. The electronic structure calculation revealed a half-metallic nature of this compound, and the observed large MR under low magnetic field is attributed to spin-polarized tunneling or spin-dependent scattering effects at grain boundaries.

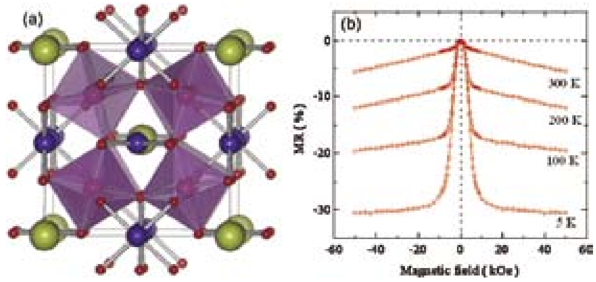

Figure 2. (a) Crystal structure of $BiCu_3Mn_4O_{12}$. (b) Electric resistivity in applied field at 5, 100, 200 and 300 K.

Epitaxial Growth and *B*-site Cation Ordering in Layered Double Perovskite La_2CuSnO_6 Thin Films

Epitaxial thin films of layered double perovskite La_2CuSnO_6 were fabricated on 001 –oriented $SrTiO_3$, $(LaAlO_3)_{0.3}$–$(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ (LSAT), and $LaAlO_3$ substrates with a pulsed laser deposition method. *B*-site cation ordering of the layer structure can be controlled by tuning the substrate temperature during deposition. X-ray diffraction and scanning transmission electron microscopy revealed that the lattice parameters were strongly correlated with the degree of Cu/Sn ordering. The relationship between the lattice parameters and the *B*-site cation ordering originates in the orientation of the Jahn-Teller distorted CuO_6 octahedra.

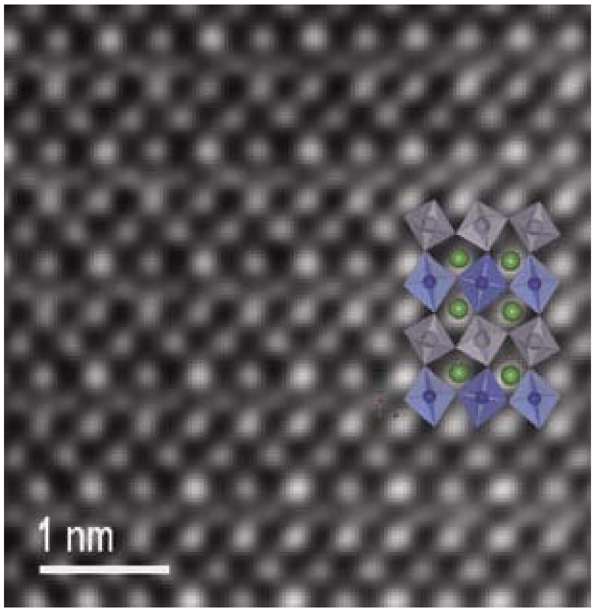

Figure 3. Scanning transmission electron microscope (STEM)-high-angle annular dark-field (HAADF) image of the layered double perovskite LCSO film grown on the LSAT substrate.